

## Reduced attentional blink for alcohol-related stimuli in heavy social drinkers


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## Abstract

Researchers have used various paradigms to show that attentional biases for substance-related stimuli are an important feature of addictive behaviors (e.g. Field & Cox, 2008). However, it is not clear whether these attentional biases occur at the level of encoding or at later post-attentive processing stages. We examined attentional bias at the level of encoding with the attentional blink (AB) paradigm (Raymond et al., 1992) in a sample of non-clinical heavy and light drinking students. Our results show a diminished AB effect for alcohol-related words compared to soft drink-related words among heavy drinkers. The AB was equally strong for alcohol-related and soft drink-related words among light drinkers. This suggests that alcohol-related information is processed relatively more efficiently in the former group. Even though these results are promising, our study shows that the internal consistency of the AB can be improved.

Keywords: attentional blink, addiction, alcohol

## Introduction

Addiction is assumed to be associated with an attentional bias toward drug-related cues. Furthermore, it is reasoned that this attentional bias is automatic in the sense that it occurs at early levels of processing that are difficult to control (e.g. Field & Cox, 2008). Franken (2003) states that “the maintenance of addictive behaviors may be the result of an enhanced likelihood to detect and become aware of drug cues” (p. 572). Several paradigms have been used to measure attentional bias in the context of addiction.

The most widely used paradigm is the addiction-Stroop task. In this task, colored neutral and drug-related words are presented, and participants are required to name the ink color. The common finding is that addicts but not non-addicted controls take more time to name the color of the drug-related words than the color of neutral, drug-unrelated words (for overviews, see Bruce and Jones, 2006, and Cox, Fadardi, and Pothos, 2006). Effects in the addiction Stroop task have proven to be a valid measure in the sense that they correlate with indices of addictive behaviors such as measures of problem drinking (e.g. Ryan, 2002). Moreover, addiction Stroop effects have been used to predict whether alcohol abusers complete treatment (Cox, Hogan, Kristian, & Race, 2002). However, on the basis of these findings, we cannot draw the conclusion that processing of addiction-related information by addicts is biased at early levels of processing. As is noted by Ryan (2002), addiction Stroop effects may be due to the ruminative processes, that is, difficulty to disengage attention from addiction-related stimuli, rather than to enhanced encoding of these stimuli. Moreover, it is possible that addiction Stroop effects are due to interference at response selection stages rather than at the stage of encoding (e.g. Mogg & Bradley, 1998).

Another paradigm that has been widely used to study attentional bias in the context of addiction is the dot probe task. In this task, participants are simultaneously presented with one neutral and one drug-related stimulus. Subsequently, a probe appears at either the location of

the neutral stimulus or at the location of the drug-related stimulus, and participants are required to indicate the location of this probe as fast and accurately as possible. The common finding in these tasks is that addicts (but not controls) are quicker to respond to the probe when it is presented in the same location as the drug-cue than when it is presented in the same location as the neutral stimulus (e.g. Ehrman et al., 2002). These effects are found usually with relatively long stimulus onset asynchronies (SOA), after the cue has crossed the threshold of consciousness (Field, 2006), but not with short SOAs (but see Noël et al., 2006). As is noted by Field and Cox (2008), effects at long SOAs are thought to reflect problems in disengaging from drug-cues, while effects at short SOAs reflect a bias in the shifting of attention toward drug-cues. It is generally accepted, however, that the performance in the dot probe paradigm does not allow us to draw conclusions on the efficiency with which stimuli gain access to awareness. Furthermore, we do not know whether interindividual differences in dot probe effects for drug-related stimuli are reliable. Schmukle (2005) has shown that dot-probe effects provide an unreliable index of attentional bias for threatening stimuli in non-clinical samples, so it is possible that dot probe indices of attentional bias for appetitive stimuli like drug-related stimuli are unreliable also when obtained from non-clinical samples.

Other less often used paradigms are dual-task paradigms. Waters and Green (2003), for instance, performed a study in which abstinent alcohol abusers and control participants were presented with two tasks. Participants were required to make an odd/even decision to a number that appeared in the center of a computer screen. Simultaneously, a lexical decision task was presented in the periphery, consisting of alcohol-related words, neutral words, and non-words. The results of Waters and Green (2003) showed that abstinent alcohol abusers performed worse on the odd/even decision task when alcohol words were presented in the periphery. Moreover, their reaction times on the lexical decision task were slower when alcohol-related words were presented. This finding can be interpreted as an indication of

attentional interference. Participants' attention is directed toward the addiction-related information, which conflicts with the primary task. However, another possible explanation is that participants try to avoid the addiction-related information, and that this process interferes with performance on the main task (e.g. Field & Cox, 2008). This paradigm therefore does not allow us to draw clear conclusions on what components of attention are affected by addiction-related information.

A final paradigm that has recently been used is the flicker-induced change blindness paradigm (e.g. Jones, Jones, Blundell & Bruce, 2002) in which two slightly different versions of a visual scene are repeatedly presented in quick succession until participants detect the change. Generally, substance-related changes are detected more quickly by participants who report to use this particular substance more often. The explanation for this finding is that these participants preferentially allocate attention to the substance-related scene, which makes it easier to detect changes occurring in this scene. Again, on the basis of this paradigm, we cannot be sure that substance-related information is more efficiently encoded.

We can thus state that the hypothesis that drug-related cues are processed more efficiently (i.e., that they have a special attentional status at the level of encoding) has not yet been tested adequately. As Anderson (2005) notes, we cannot attribute a special attentional status to such stimuli unless we manipulate the degree of available attentional resources. One paradigm that allows for this manipulation is the attentional blink (AB) paradigm. The AB was first reported by Raymond, Shapiro and Arnell (1992) and refers to the finding that the second of two masked targets (T1 and T2) in a rapid serial visual presentation (RSVP) stream of distractors, is usually identified poorly when it is presented within a short temporal interval (lag) after T1 (within 500 ms). As lag increases, T2 performance recovers.

Several theories explain the AB by stressing the limited capacity of our attentional system. The common idea is that our attentional resources are not sufficient to deal with all

RSVP items and that there is competition between these items in encoding stages of attention (e.g. Chun & Potter, 1995; Giesbrecht & Di Lollo, 1998; Isaak, Shapiro, & Martin, 1999; Jolicoeur & Dell'Acqua, 1998; Raymond et al., 1992; Shapiro, Arnell, & Raymond, 1997; Shapiro, Raymond, & Arnell, 1994). Several studies have shown that the AB is attenuated for highly arousing T2 words (Anderson, 2005; Anderson & Phelps, 2002; Keil & Ihssen, 2004; Keil, Ihssen, & Heim, 2006). Other studies have shown that participants' own name (Shapiro, Caldwell, & Sorensen, 1997), familiar faces (Jackson & Raymond, 2006), and negatively valenced ideographs (Ogawa & Suzuki, 2004) "survive" the AB as well.

Recently, the AB has been used as a measure of interindividual differences. Fox, Russo, and Georgiou (2005) have shown that the AB is diminished for fearful T2 faces in a group of highly anxious participants. A study by Trippe, Hewig, Heydel, Hecht, and Miltner (2007) has shown that the AB is reduced also for spider-pictures in a sample of spider-phobics. Moreover, Waters, Heishman, Lerman, and Pickworth (2007) found that the AB was attenuated for nicotine-related words in a sample of smokers. However, in the latter study, no control group of non-smokers was tested. Another study in which the AB was used to measure attentional bias in the context of addiction was performed by Liu, Li, Sun, Hu, and Ma (2008). In their study, a group of abstinent opiate dependent patients (AODPs) and a control group participated in an AB task with neutral, addiction-related, and negative T2 words. However, even though the authors state that the AODPs showed a reduced AB for addiction-related stimuli, they do not report a significant interaction between Lag (early or late), T2 type (neutral, addiction-related, or negative), and Group (AODP or control). Their study thus does not allow us to draw clear conclusions on the modification of the AB for addiction-related information. Finally, a study by Heinz et al. (2007) examined effects of nicotine-deprivation on a standard AB task (i.e. with only neutral words). They found no differences in AB between non-smokers, deprived smokers, and non-deprived smokers.

The studies described above show that the AB can thus be used to examine to what extent stimuli need attentional resources to gain access to consciousness: the fact that certain T2 stimuli are identified accurately regardless of the temporal lag between T1 and T2 shows that these stimuli are processed more efficiently. The aim of the present study is to examine whether alcohol-related words are processed more efficiently than neutral words by heavy compared to light social drinkers. We examined this by presenting T2 words that either referred to alcoholic beverages or to soft drinks. For heavy social drinkers, we expected a strong AB for soft drink-related words but an attenuation of the AB for alcohol-related words. For light drinkers, we expected a strong AB for both types of T2 stimuli. Because the use of the AB as a measure of interindividual differences is a very recent development, its reliability and validity have not yet been explored. While internal consistency is usually not examined in studies concerning attentional bias for drug-cues, it is very important to explore this psychometric property because it is an important determinant of how useful the measure is for capturing stable interindividual differences and for predicting future behavior. Therefore, the second aim of this study was to examine whether the internal consistency of our version of the AB task is satisfactory. In addition, we examined whether interindividual differences in the modulation of the AB were related to indices of alcohol abuse and subjective craving, as these should be positively correlated (Field & Cox, 2008).

## Method

### *Participants*

Thirty-six first year psychology students at Ghent University participated in exchange for course credits. They were invited on the basis of data of an online pre-screening survey according to the guidelines for sensible drinking (Edwards, 1996). Male participants were invited if they indicated that they drank more than 21 (heavy drinkers) or less than 5 (light

drinkers) standard units of alcohol in a week. Female participants were invited if they drank more than 14 or less than 5 units a week.

### *Stimuli and materials*

As shown in Appendix A, there were 16 neutral T1 words, that on average had a length of 4.50 letters ( $SD = 0.89$ ), 6 alcohol-related T2 words that on average contained 4.67 letters ( $SD = 1.21$ ) and 6 soft drink-related T2 words that on average contained 6.50 letters ( $SD = 1.76$ ). The difference in word length between alcohol-related and soft drink-related words was marginally significant,  $t(10) = 2.10$ ,  $p = .06$ . We nevertheless opted to use these stimuli because using either longer alcohol-related words or shorter soft drink-related words would imply using words referring to less common drinks. This compromise is not ideal, because one may expect that T2 length affects the AB. However, it is hard to see how word length as such could be responsible for the crucial interaction between group, T2 type, and lag. We selected also 79 neutral distractors, adapted from stimuli used by Anderson (2005), that were long enough ( $M = 12.73$  letters,  $SD = 2.07$ ) to mask the targets.

### *Procedure*

Participants were tested individually. Upon arriving at the testing room, they were provided with instructions and were given the opportunity to ask questions if any information was unclear. Participants were seated in front of a 17 inch CRT-monitor with a refresh rate of 85 Hz, at a distance of approximately 45 cm. For stimulus presentation and response registration we used the Inquisit software package (Millisecond Software, 2001). After signing the informed consent form, participants performed the AB task.

Each trial started with the presentation of a red fixation cross, that remained on the screen for 1000 ms. This was followed by the RSVP stream, consisting of 13 distractor words in white, and T1 and T2 in green. All stimuli were presented consecutively for 100 ms in 16 point bold Courier New font, against a black background. The interstimulus interval (ISI) was



10 ms. Participants were instructed to monitor the stream and to report the green words. At the end of each trial, participants were prompted to type in their responses. They were encouraged to guess when appropriate. There was no response deadline.

T1 was always selected from the neutral list of T1 stimuli. T2 was selected from the list of alcohol-related words on half of the trials, and from the list of soft drink-related words on the other half of the trials. Selection from the lists was random without replacement and the different types of trials were presented in a random order as well. T1 could appear at the third, fourth, or fifth position in the stream, and T2 could appear 2, 4, or 6 lags after T1, reflecting SOAs of 220, 440, and 660 ms respectively. There were 12 presentations of each of these two types of T2, for each of the three lags and each of the three T1 positions, resulting in 216 experimental trials. At the beginning of the experiment, there was a practice block consisting of 18 trials in which all targets were neutral words.

After the AB task, participants were required to fill in Dutch translations of the Alcohol Use Disorders Identification Test (Babor, Higgins-Biddle, Saunders, & Monteiro, 2001), the 18-item version of the Rutgers Alcohol Problem Index (White & Labouvie, 1989), and the Desires for Alcohol Questionnaire (Love, James, & Willner, 1998). Moreover, participants were again briefly asked questions regarding their weekly alcohol use, because their current drinking behavior could have changed between the time they filled in the online questionnaire and the time they participated in our study. They were asked how many glasses of beer, cognac, rum, whisky, wine, vodka, apple juice, cola, fanta, fruit juice, lemonade, and sprite they consumed in a typical week. Moreover, they were asked to indicate how many glasses of other alcoholic drinks they generally use in a week. We presented the questionnaires after the AB task because presenting them before the task might affect AB performance by making the concept of alcohol more accessible (but see Davenport & Potter, 2005, for evidence that AB performance is not affected by such priming effects).

### *Data analysis*

First, the percentage of accurate T2 responses was calculated for each of the experimental conditions. Because “whisky” was often incorrectly spelled as “whiskey” or “wisky”, we coded all three spellings as correct. Other misspellings were coded as incorrect. For the analyses discussed below, only trials with a correct T1 identification were taken into account (T2|T1-correct). When we performed the analyses on all trials, regardless of whether T1 was identified correctly, this yielded comparable results.

Second, we performed item-analyses based on an AB-index. We calculated this index by dividing performance at Lag 2 by performance at Lag 6 and multiplying this value by 100. This yielded a score reflecting the percentage of AB “survival” at the short compared to the long Lag for both T2 types. High scores imply that the “survival” rate was high and that the AB effect was thus small. We then calculated Cronbach’s alpha to check whether the alcohol-related items and the soft drink-related items measured two clear constructs, and to determine which items were suitable for further analyses.

Third, we performed a repeated measures ANOVA on the percentages of accurate T2 responses for each condition, with group as between subjects factor (heavy or light drinker) and lag (Lag 2, 4, or 6), and T2 type (alcohol or soft drink) as within-subjects factors.

Finally, we calculated split-half reliability of the modulation of the AB by addiction-related stimuli. Note that Cronbach’s alpha and split-half reliabilities are very similar, but that there is a clear difference in how they are calculated and thus what they reflect. We calculated Cronbach’s alpha on the basis of the AB indices for the alcohol- and for the soft drink-related words, to yield an index of the internal consistency of both constructs. We calculated split-half reliability on the basis of the difference between the AB indices for alcohol- and soft drink-related stimuli, to yield an index of the stability of the modulation of the AB by alcohol-related stimuli (relative to soft drink-related stimuli). We divided the trials into two sets on the

basis of whether the trial position was odd- or even-numbered. We then calculated the AB-index for both the alcohol- and the soft drink-related stimuli and subsequently calculated a bias-index by subtracting the AB-index for soft drink-related words from the AB-index for alcohol-related words. Positive scores thus reflected a smaller AB for alcohol-related words than for soft drink-related words, negative scores reflected a smaller AB for soft drink-related words than for alcohol-related words. We did this for both halves and then calculated Pearson's correlations.

## Results

We could classify 14 participants as heavy drinkers and 18 participants as light drinkers according to the guidelines for sensible drinking (Edwards, 1996). This was done on the basis of the self-reported number of alcoholic drinks consumed on a weekly basis, as measured by the questionnaire at the end of the session. Four participants could not be classified as being a heavy or a light drinker, because they were either men who reported to drink more than 5 and less than 21 units of alcohol a week, or women who reported to drink more than 5 and less than 14 units of alcohol a week. Heavy drinkers had a higher score than light drinkers on the AUDIT,  $t(30) = 7.24, p < .001$ , on the RAPI,  $t(30) = 5.52, p < .001$ , and on the DAQ,  $t(30) = 3.79, p < .005$  (see Table 1). The identification of T1 did not differ between conditions, all  $F < 1.3$ . Overall, T1 performance was good,  $M = .95, SE = .01$ .

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Insert Table 1 about here.  
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We calculated Cronbach's alpha on the basis of the AB-index separately for the alcohol-related words and the soft drink-related words, for each participant. We included the four participants who could not be classified as being a heavy or light drinker for our analyses concerning validity and internal consistency because we did not want to artificially increase

correlations by including only extreme groups. However, results were similar when the four subjects that did not fit into the heavy or light drinker-category were excluded. For the alcohol-related words, this resulted in a Cronbach's alpha of  $\alpha = .12$ . This implies that the different alcohol-related items did not actually measure a similar construct. For the soft drink-related words, Cronbach's alpha was  $\alpha = -.06$ , which indicates that the items are not equivalent, the covariance between some of the items is negative. Because Cronbach's alpha was low for both the alcohol- and the soft drink-related stimuli, we examined whether these values increased when we excluded items with weak or negative inter-item correlations. The largest increase in Cronbach's alpha was achieved by removing the items "wijn" (wine), "rum", "sprite", and "fanta" from our analyses. Removing these items yielded a Cronbach's alpha of  $\alpha = .53$  for the alcohol-related words and  $\alpha = .40$  for the soft drink-related words. Because the removal of these stimuli optimized the internal consistency of our measure, in all reported analyses, we excluded the data of trials on which these stimuli were presented. Note, however, that we performed our repeated measures ANOVA also including all items. This analysis yielded similar results. Average length of the words in both stimulus categories was thus slightly increased, resulting in an average of 5.25 for the alcohol-related words ( $SD = .96$ ), and an average of 7.00 letters for the soft drink-related words ( $SD = 2.00$ ). These values did not differ significantly from each other,  $t(6) = 1.58, p = .17$ .

We performed a repeated measures ANOVA, excluding the four participants that could not be classified as being a heavy or a light drinker. Most importantly, this yielded a significant interaction between T2 type, lag, and drinker status,  $F(2, 29) = 7.46, p < .005, \eta^2 = .18$  (for the relevant means, see Table 2). When we analysed performance at Lag 2, this yielded a significant interaction,  $F(1, 30) = 6.93, p < .05, \eta^2 = .43$ . This interaction was not significant at Lag 4,  $F = 1.90$ , and at Lag 6,  $F = 1.60$ . The ANOVA also revealed some less important effects. The interaction between T2 type and lag approached significance,  $F(2, 29)$

= 2.40,  $p = .10$ ,  $\eta^2 = .07$ , as well as the interaction between lag and group,  $F(1, 30) = 2.57$ ,  $p = .11$ ,  $\eta^2 = .07$ . Moreover, there was a main effect for lag,  $F(2, 29) = 27.74$ ,  $p < .001$ ,  $\eta^2 = .43$ , and a main effect for T2 type,  $F(1, 30) = 11.56$ ,  $p < .005$ ,  $\eta^2 = .25$ . There was no interaction between T2 type and group,  $F < 1$ . The main effect for group failed to reach significance,  $F(1, 30) = 2.84$ ,  $p = .10$ ,  $\eta^2 = .08$ . To further explore the three-way interaction, we performed separate analyses for the two groups.

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#### *Heavy drinkers*

Among the heavy drinkers, the crucial interaction between T2 type and lag was significant,  $F(2, 12) = 7.79$ ,  $p < .01$ ,  $\eta^2 = .22$ , revealing a smaller AB effect for alcohol-related words compared to soft drink-related words. Paired-samples t-tests show that for alcohol-related stimuli, the difference between Lag 2 and Lag 4 was only marginally significant,  $t(13) = 1.91$ ,  $p = .08$ , while neither Lag 2 nor Lag 4 differed significantly from Lag 6,  $ts < 1.30$ . Conversely, for the soft drink-related words, there was a highly significant difference between Lag 2 and Lag 4,  $t(13) = 5.72$ ,  $p < .001$ , and between Lag 2 and Lag 6,  $t(13) = 4.68$ ,  $p < .001$ , but not between Lag 4 and Lag 6,  $t < 1$ . The difference between alcohol-related words and soft drink-related words was significant on Lag 2,  $t(13) = 4.11$ ,  $p < .005$ , but not on Lag 4 and Lag 6,  $ts < 1$ .

There were also less important main effects. The main effect for lag was significant,  $F(2, 12) = 20.60$ ,  $p < .001$ ,  $\eta^2 = .37$ , indicating that the percentage of correct identifications of T2 increased with lag. There was also a main effect for T2 type,  $F(1, 13) = 28.72$ ,  $p < .001$ ,  $\eta^2 = .41$ , reflecting better performance for the alcohol-related words.

#### *Light drinkers*

Among the light drinkers, the crucial interaction between T2 type and lag was not significant,  $F < 1$ . There was a significant main effect for lag,  $F(2, 16) = 11.34, p < .005, \eta^2 = .67$ . Performance was significantly better at Lag 4 compared to both Lag 2,  $t(17) = 2.43, p < .05$ . Similarly, performance at Lag 6 was better than performance at Lag 2,  $t(17) = 3.82, p < .005$ . and Lag 4,  $t(17) = 3.90, p < .005$ . The main effect for T2 type approached significance,  $F(1, 17) = 3.01, p = .10, \eta^2 = .25$ , reflecting a tendency for better performance for alcohol-related words.

#### *Split-half reliability*

We calculated Pearson's correlation between AB-indices for even- and odd-numbered trials, for all participants, including the four participants that were initially left out. The correlation between the two indices was not satisfactory,  $r(36) = .19, p = .27$ . When we calculated split-half reliability separately for the two categories this yielded a significant correlation for the alcohol-related words,  $r(36) = .47, p < .005$ , but not for the soft drink-related words,  $r(36) = .04, p = .82$ .

#### *Validity*

We checked the construct validity of our modified AB task by calculating correlations between the bias-index and the AUDIT, the RAPI, and the DAQ (again including the four participants who could not be classified as being a heavy or light drinker). The bias-index correlated significantly with the RAPI,  $r(36) = .43, p < .01$ , and with the AUDIT,  $r(36) = .41, p < .05$ , but not with the DAQ,  $r(36) = .15$ . There were strong correlations between RAPI and AUDIT scores,  $r(36) = .86, p < .001$ , AUDIT and DAQ,  $r(36) = .45, p < .01$ , and RAPI and DAQ,  $r(36) = .49, p < .005$ .

### Discussion

The aim of the present study was to examine whether heavy social drinkers encode alcohol-related information more efficiently than soft drink-related information (i.e., they

need less attentional resources to become aware of alcohol-related items). Our results show that for heavy drinkers, the typical AB effect (i.e., worse T2 performance on the short compared to the long Lags) was smaller for alcohol-related T2 stimuli than for soft drink-related T2 stimuli. This suggests that for heavy drinkers, alcohol-related words indeed have better access to conscious awareness than soft drink-related words. When attentional resources are depleted (i.e. at Lag 2), alcohol-related information is more likely to be encoded than soft drink-related information. This effect was specific for heavy drinkers. For light drinkers, we found a highly significant AB that was equally strong for alcohol- and soft drink-related words.

To our knowledge, this is the first study to show that alcohol-cues may have a special attentional status for heavy drinkers at the level of encoding. Previous studies on attentional bias have looked only at the spatial allocation of attention or the interruption of responses as the result of the presentation of addiction-related stimuli (see Field and Cox, 2008, for a review). Our findings go beyond those of previous studies by showing that addiction-related stimuli are processed more efficiently when presented at the focus of attention under conditions of high cognitive load. The stronger impact of addiction-related stimuli on the spatial allocation of attention and on behavioral responses might even be due to the fact that these stimuli are processed more efficiently. Stimuli that are processed more efficiently could indeed be more likely to influence subsequent cognition and behavior. As such, our findings provide an important new step toward a better understanding of the cognitive processes underlying addiction.

The question remains what underlying mechanism drives the enhanced encoding of alcohol-related information by heavy drinkers. Several theories suggest that the motivational relevance of such stimuli facilitates attentional processing (e.g. Cox et al., 2006; Franken, 2003; McCusker, 2001; Robinson & Berridge, 2001, 2003, 2008). This idea is supported by

the finding that attentional biases seem to be stronger when participants experience craving at the time of testing (see Field & Cox, 2008, for a review). However, our data do not provide clear evidence for the role of motivational relevance. Even though we find a differential modulation of the AB by addiction-related information and there is a significant difference in subjective craving (as measured with the DAQ) between the two groups, we do not find a correlation between our AB index and craving. Although the absence of this correlation could be due to a number of factors, it does raise some doubt about the hypothesis that the observed modulation of the AB effect was mediated by the motivational relevance of the stimuli.

There are several alternative mechanisms that could be responsible for our findings. As we noted above, previous research shows that the AB is diminished both for familiar T2s such as participants' own name (Shapiro et al., 1997) or famous faces (Jackson & Raymond, 2006) and for highly arousing stimuli (e.g. Anderson, 2005). It is possible that the modulation of the AB effect that we observed, was due to the familiarity (i.e. heavy drinkers may have been more familiar with alcohol-related stimuli than light drinkers) or the emotional properties of the stimuli (i.e. heavy drinkers found alcohol-related stimuli more arousing). These hypotheses could be tested in future research, for instance, by adding familiarity and arousal ratings at the end of the experimental session and examining the relation between these ratings and the modulation of the AB effect.

One may suggest that the differential modulation of the AB for heavy and light drinkers is not due to an attentional bias, but to the fact that heavy drinkers are better at spelling the alcohol-related words. However, if this is the case, we would expect differences at the later Lags as well, whereas a difference was found only on Lag 2. Moreover, heavy drinkers may have a post-attentional bias to report alcohol-related words. For instance, under conditions when stimulus presentation is degraded (i.e. when stimuli are presented at Lag 2), it is likely that words are incompletely perceived by both heavy and light drinkers. Heavy



drinkers may be inclined to complete such words in an alcohol-related manner, while light drinkers may be inclined to complete such words in a soft drink-related manner. Studies using word stem completion tasks have indeed shown that addiction is associated with a stronger tendency to complete word stems in an addiction-related manner (e.g. McCusker, 2001).

Such a bias would become evident on Lag 2 trials in which T2 was incorrectly identified. For these trials, we assessed response bias in a similar way as Anderson (2005), by calculating the percentage of trials in which T2 was incorrectly reported as either an alcohol-related word or a soft drink-related word. We then performed a repeated measures ANOVA with group (heavy or light drinker) as a between-subjects factor and response type (alcohol or soft drink) as a within-subjects factor. These analyses show that there was no interaction between group and response type,  $F < 1$ . Thus, under conditions of stimulus degradation, heavy drinkers were not biased to report alcohol-related words. The results can be found in Appendix B.

Another aim of our study was to provide a preliminary examination of the internal consistency and validity of the modulation of the AB by drug-cues. Our item-analyses show that Cronbach's alpha was initially small, implying that internal consistency was insufficient. The low Cronbach's alpha was due to the fact that inter-item correlations were very low for some items (wine and rum for the alcohol-category; fanta and sprite for the soft drink-category), suggesting that these items did not measure the construct that we intended to measure. Even though each of the items clearly referred to either an alcoholic or a soft drink, it is possible that only some of these items activated the emotional content that is associated with these drinks. It is likely that only items that activate this emotional content can influence attention and thus modulate the AB. Emotional salience of stimuli may be determined by personal relevance, that is, whether a participant actually consumed a certain beverage on a regular basis. For future studies it is thus advisable to take care in selecting the target stimuli.

We suggest the use of individually selected items (e.g. drinks that are consumed most often by individual participants), or items that are personally relevant for all participants.

Another possible explanation for the low Cronbach's alpha is that specific lexical properties, like word length, affected the internal consistency. From this perspective, it is interesting to note that alcoholic drinks with short names (wine and rum) had very low correlations with the other alcohol items. Moreover, the fact that variance was very small due to near-ceiling performance may have decreased inter-item correlations, thereby decreasing Cronbach's alpha. Finally, the limited sample size could have adversely affected the validity of the psychometric analyses.

After exclusion of items with a low consistency, Cronbach's alpha increased dramatically. However, even after optimizing the internal consistency of our measure, split half reliability remained low. This was mostly due to the poor reliability of the effects on trials with soft drink-related items. A possible explanation for this result is that our participants did not differ in a meaningful way with regard to their attentional responses toward soft drink-related items. In the absence of systematic interindividual differences, measures of those differences reflect mainly error variance and are therefore unreliable. This explanation is in line with the finding that split half reliability was markedly better when considering only responses to alcohol-related items. Such a result can be expected because we selected participants who can be assumed to differ systematically in their attentional response to alcohol-related items (i.e., heavy and light drinkers). Despite the low split-half reliability, we did obtain evidence for the construct validity of our AB measure. Most importantly, the bias-index correlated significantly with the RAPI and AUDIT. However, as mentioned above, there was no correlation with the DAQ, suggesting that this version of the AB task is not associated with measures of craving. However, we must note that participants did not report very high levels of craving. This may be due to the fact that participants were tested in a

neutral laboratory setting during office hours. For non-clinical social drinkers, this setting probably does not elicit craving for alcohol.

There is still room for improving our AB measure. An important aim should be to improve internal consistency and split half reliability. One way to achieve this is through careful selection of target stimuli. It is also likely that effects might be bigger and more reliable for clinical groups. Moreover, the sample size in this study was relatively small. Finally, in the present study, the size and reliability of the effects might have been reduced because of the overall highly accurate performance of the participants. At Lags 4 and 6, performance even approached ceiling. There are several reasons why this might be the case. First, SOAs were relatively long, making it easier to identify the targets. In line with this idea, we found much better performance when we used shorter SOAs in other studies conducted at our lab. Second, there were only 16 different T1 stimuli that were often repeated. Participants may thus have come to expect these stimuli, making the task more easy. This may affect overall performance and may also decrease the AB (e.g. Seiffert & Di Lollo, 1997). Third, there were only 12 different T2 stimuli. Again, we may expect that repeated presentation of these targets decreased task difficulty and increased performance. Nevertheless, near-ceiling performance did not pose an insurmountable problem, because the hypothesized three-way interaction did reach significance. The reported results show that even in its present form, our adaptation of the AB task provides a useful tool for the study of attentional processes related to alcohol use.

#### Author note

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## References

- Anderson, A. K., 2005. Affective influences on the attentional dynamics supporting awareness. *J Exp Psychol Gen*, 134, 258-281.
- Anderson, A. K., & Phelps, E. A., 2001. Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature* 411, 305-309.
- Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Monteiro, M. G., 2001. The alcohol use disorders identification test: Guidelines for use in primary care, second edition. Geneva: World Health Organization.
- Bruce, G., & Jones, B. T. 2006. Methods, measures, and findings of attentional bias in substance use, abuse, and dependence. In R. W. Wiers & A. W. Stacy (Eds.), *Handbook of implicit cognition and addiction*. Thousand Oaks, CA: Sage, pp. 135-149.
- Chun, M. M., & Potter, M. C., 1995. A 2-stage model for multiple-target detection in rapid serial visual presentation. *J Exp Psychol Human Perc Perf*. 21, 109-127.
- Cox, W. M., Fadardi, J. S., & Pothos, E. M., 2006. The Addiction-Stroop Test: Theoretical considerations and procedural recommendations. *Psychol Bull*. 132, 443-476.
- Cox, W. M., Hogan, L. M., Kristian, M. R., & Race, J. H., 2002. Alcohol attentional bias as a predictor of alcohol abusers' treatment outcome. *Drug Alcohol Depend*. 68, 237-243.
- Davenport, J. L., & Potter, M. C., 2005. The locus of semantic priming in RSVP target search. *Mem & Cogn*. 33, 241-248.
- Edwards, G., 1996. Sensible drinking. *BMJ* 312, 1.
- Ehrman, R. N., Robbins, S. J., Bromwell, M. A., Lankford, M. E., Monterosso, J. R., & O'Brien, C. P., 2002. Comparing attentional bias to smoking cues in current smokers, former smokers, and non-smokers using a dot-probe task. *Drug Alcohol Depend*. 67, 185-191.

- Field, M., 2006. Attentional biases in drug abuse and addiction: cognitive mechanisms, causes, consequences and implications. In: M. R. Munafò & I. P. Albery (Eds.), *Cognition and addiction*. Oxford, UK: Oxford University Press, pp. 73-99.
- Field, M., & Cox, W. M., 2008. Attentional bias in addictive behaviors: A review of its development, causes, and consequences. *Drug Alcohol Depend.* 97, 1-20.
- Franken, I. H. A., 2003. Drug craving and addiction: integrating psychological and neuropsychopharmacological approaches. *Prog Neuro-Psychopharmacol Biol Psychiatry* 27, 563-579.
- Fox, E., Russo, R., & Georgiou, G. A., 2005. Anxiety modulates the degree of attentive resources required to process emotional faces. *Cogn Aff Behav Neurosci.* 5, 396-404.
- Giesbrecht, B., & Di Lollo, V., 1998. Beyond the attentional blink: Visual masking by object substitution. *J Exp Psychol Human Perc Perf.* 24, 1454-1466.
- Heinz, A., Waters, A. J., Taylor, R. C., Myers, C. S., Moolchan, E. T., & Heishman, S. J., 2007. Effect of tobacco deprivation on the attentional blink in rapid serial visual presentation. *Huma Psychopharmacol Clin Exp*, 22, 89-96.
- Isaak, M. I., Shapiro, K. L., & Martin, J., 1999. The attentional blink reflects retrieval competition among multiple rapid serial visual presentation items: Tests of an interference model. *J Exp Psychol Human Perc Perf.* 25, 1774-1792.
- Jackson, M. C., & Raymond, J. E., 2006. The role of attention and familiarity in face identification. *Perc Psychophysics* 68, 543-557.
- Jolicoeur, P., & Dell'Acqua, R., 1998. The demonstration of short-term consolidation. *Cogn Psychol.* 36, 138-202.
- Jones, B. C., Jones, B. T., Blundell, L., & Bruce, G., 2002. Social users of alcohol and cannabis who detect substance-related changes in a change blindness paradigm report

- higher levels of use than those detecting substance-neutral changes. *Psychopharmacol.* 165, 93-96.
- Keil, A., & Ihssen, N., 2004. Identification facilitation for emotionally arousing verbs during the Attentional Blink. *Emotion* 4, 23-35.
- Keil, A., Ihssen, N., & Heim, S., 2006. Early cortical facilitation for emotionally arousing targets during the attentional blink. *BMC Biol.* 4, 23.
- Liu, N., Li, B., Sun, N., & Ma, Y., 2008. Effects of addiction-associated and affective stimuli on the attentional blink in a sample of abstinent opiate dependent patients. *J Psychopharmacol.* 22, 64-70.
- Love, A., James, D., & Willner, P., 1998. A comparison of two alcohol craving questionnaires. *Addiction* 93, 1091-1102.
- McCusker, C. G., 2001. Cognitive biases and addiction: an evolution in theory and method. *Addiction* 96, 47-56.
- Millisecond Software., 2001. Inquisit 1.32 [Computer software]. Seattle, WA: Author.
- Mogg, K., & Bradley, B. P., 1998. A cognitive-motivational analysis of anxiety. *Behav Res Therapy* 36, 809-848.
- Noël, X., Van der Linden, M., Bechara, A., Bullens, Q., Hanak, C., & Verbanck, P., 2006. Time course of attention for alcohol cues in abstinent alcoholic patients: The role of initial orienting. *Alcohol Clin Exp Res.* 30, 1871-1877.
- Ogawa, T., & Suzuki, N., 2004. On the saliency of negative stimuli: Evidence from attentional blink. *Jap Psychol Res.* 46, 20-30.
- Raymond, J. E., Shapiro, K., & Arnell, K. M., 1992. Temporary suppression of visual processing in an RSVP task: An attentional blink? *J Exp Psychol Human Perc Perf.* 18, 849-860.

- Robinson, T. E., & Berridge, K. C. (2001). Mechanisms of action of addictive stimuli: Incentive-sensitization and addiction. *Addiction*, 96, 103-114.
- Robinson, T. E., & Berridge, K. C. (2003). Addiction. *Annual Review of Psychology*, 54, 1-29.
- Robinson, T. E., & Berridge, K. C. (2008). The incentive sensitization theory of addiction: some current issues. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 363, 3137-3146.
- Ryan, F., 2002. Attentional bias and alcohol dependence: A controlled study using the modified Stroop paradigm. *Addict Behav.* 27, 471-482.
- Schmukle, S. C., 2005. Unreliability of the Dot Probe Task. *Eur J Pers.* 19, 595-605.
- Seiffert, A. E., & DiLollo, V., 1997. Low-level masking in the attentional blink. *J Exp Psychol Human Perc Perf.* 23, 1061-1073.
- Shapiro, K. L., Arnell, K. M., & Raymond, J. E., 1997. The attentional blink. *TRENDS Cogn Sci.* 1, 291-296.
- Shapiro, K. L., Caldwell, J., & Sorensen, R. E., 1997. Personal names and the attentional blink: A visual "cocktail party" effect. *J Exp Psychol Human Perc Perf.* 23, 504-514.
- Shapiro, K. L., Raymond, J. E., & Arnell, K. M., 1994. Attention to Visual-Pattern Information Produces the Attentional Blink in Rapid Serial Visual Presentation. *J Exp Psychol Human Perc Perf.* 20, 357-371.
- Trippe, R. H., Hewig, J., Heydel, C., Hecht, H., & Miltner, W. H. R., 2007. Attentional Blink to emotional and threatening pictures in spider phobics: Electrophysiology and behavior. *Brain Res.* 1148, 149-160.
- Waters, H., & Green, M. W., 2003. A demonstration of attentional bias, using a novel dual task paradigm, towards clinically salient material in recovering alcohol abuse patients? *Psych. Med.* 33, 491-498.



Waters, A. J., Heishman, S. J., Lerman, C., & Pickworth, W., 2007. Enhanced identification of smoking-related words during the attentional blink in smokers. *Addict Behav.* 32, 3077-3082.

White, H. R., & Labouvie, E. W., 1989. Towards the Assessment of Adolescent Problem Drinking. *J Studies Alcohol* 50, 30-37.

## Appendix A

### Stimuli

#### *T1 words:*

BANK (couch), BED (bed), DAK (roof), DEUR (door), HUIS (house), KAMER (room), KEUKEN (kitchen), KLEED (rug), KRUK (stool), MUUR (wall), SALON (salon), SOFA (sofa), STOEL (chair), TAFEL (table), VLOER (floor), ZOLDER (attic)

#### *Alcohol T2 words:*

BIER (beer), COGNAC (cognac), RUM (rum), WHISKY (whisky), WIJN (wine), WODKA (vodka).

#### *Softdrink T2 words:*

APPELSAP (apple juice), COLA (coke), FANTA (fanta: orange flavoured soda), FRUITSAP (fruit juice), LIMONADE (lemonade), SPRITE (sprite: lemon-lime flavoured soda).

## Appendix B

### Response bias analyses

If heavy drinkers were biased to report alcohol-related words and light drinkers were biased to report softdrink-related words, we would expect that a group (heavy or light drinker) \* response type (alcohol-related, softdrink-related) repeated measures ANOVA on the incorrect responses on Lag 2 would yield a significant interaction between group and response type. However, this was not the case,  $F < 1$ . Moreover, there was no effect for response type,  $F < 1$ . However, there was a marginally significant main effect for group,  $F(1, 28) = 3.74$ ,  $p = .06$ ,  $\eta^2 = .14$ . Heavy drinkers reported both more alcohol- and softdrink-words,  $M = .30$ ,  $SD = .17$ , than light drinkers,  $M = .19$ ,  $SD = .13$ .

Table 1

*Group means for questionnaires*

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Group	Questionnaire	
	<i>M</i>	<i>SD</i>
<hr/> AUDIT		
Heavy drinkers	14,71	3,83
Light drinkers	5,00	3,71
<hr/> RAPI		
Heavy drinkers	16,14	7,85
Light drinkers	3,44	3,99
<hr/> DAQ		
Heavy drinkers	1,58	0,79
Light drinkers	0,69	0,77

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Table 2

*Mean T2 accuracy given correct identification of T1, after the exclusion of 4 stimuli*

T2 type	Lag 2		Lag 4		Lag 6	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Heavy drinkers						
Alcohol	0,96	0,05	0,99	0,02	0,99	0,04
Softdrink	0,88	0,07	0,99	0,02	0,98	0,03
Light drinkers						
Alcohol	0,92	0,07	0,97	0,05	0,99	0,02
Softdrink	0,92	0,09	0,94	0,05	0,96	0,03